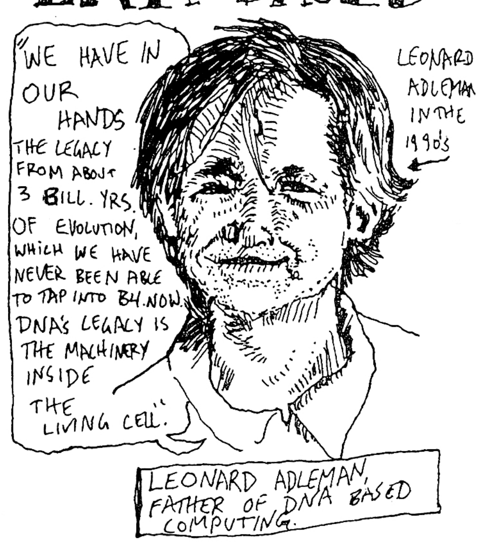
DNA BASED

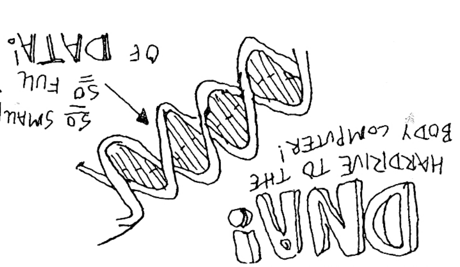


COMPUTING

THE FUTURE OF COMPUTERS!

INTRODUCTION

The computers we use today to check our email and search the web run on silicon based microprocessors. They are becoming faster, smaller and lighter with each generation as scientists continue to find new ways of improving the speed and storage capacity of silicon, BUT! there is a material which has an even greater capacity for storage and speed in computing; DNA! The computers we use now, store everything as a series of 1s and 0s in what is called binary code. DNA molecules already store vast quantities of information in our bodies and in all living organisms but instead of using 1s and 0s the information is stored as a sequence of bases; Adenine, Thymine, Cytosine and Guanine. These sequences carry the information for the structure of our bodies but they can be manipulated, or "programmed," to store new information as well as solve mathematical problems. While DNA computing is not likely to replace silicon-based microprocessors (at least not in the near future), the computers of the future may be hybrids of genetic and conventional materials.



DNA COMPUTING VS. CONVENTIONAL COMPUTING

-Due to its microscopic size, DNA based computers have the potential of being several times smaller than conventional computers. More than 10 trillion DNA molecules can fit into an area no larger than 1 cubic centimeter (0.06 cubic inches). With this small amount of DNA, a computer would be able to hold 10 terabytes of data, and perform 10 trillion calculations at a time.

-Unlike the toxic materials needed to manufacture our conventional PCs DNA is abundant in all living creatures and replication of DNA to get a large quantity from a small quantity through PCR is fast and easy making it a cheaper and safer resource than those used in today's computers.

-The computing power of a teardrop-sized DNA computer, using the DNA logic gates, will be more powerful than the world's most powerful supercomputer. By adding more DNA, more calculations could be performed.
DNA based computers can make calculations and run commands in parallel rather than sequentially as today's computers, which run one command after another rather than all of them at once, although they are advanced enough that they run them so fast we do not notice.

-Unlike conventional computers, DNA computers perform calculations parallel to other calculations. Conventional computers operate linearly, taking on tasks one at a time but they run so fast today that we cannot tell. It is parallel computing that allows DNA to solve complex mathematical problems in hours, whereas it might take electrical computers hundreds of years to complete them, however it still takes an incredible amount of time to sort through the solution to find the answer.

THE HISTORY OF DNA BASED COMPUTING.

-1953, James Watson and Francis Crick discover double helix structure of DNA.
-1994, Leonard Adleman introduces the idea of using DNA to solve complex mathematical problems. Begins experiments using test tubes of DNA and DNA sequencing techniques to solve directed Hamilton Path problem, also known as the "traveling salesman" problem.
-1997, Researchers at the University of Rochester developed logic gates made of DNA. The Rochester team's DNA logic gates are the first step toward creating a computer that has a structure similar to that of an electronic PC. Genetic material is used as input and spliced together according to the gate to form output also made of genetic material. Similar electronic gates are the basis of calculators and computers.
-2002, Researchers from the Weizmann Institute of Science in Rehovot, Israel create programmable molecular computing machines composed of enzymes and DNA molecules instead of silicon.
-2003, Israeli scientists demonstrated a limited, but functioning, DNA computer. In this DNA computer the DNA molecule that provides the computer with the input data also provides all the necessary fuel.
-2004, Ehud Shapiro, Yaakov Benenson, Binyamin Gil, Uri Ben-Dor and Rivka Adar announce the construction of a DNA computer coupled with an input and output module that is capable of diagnosing cancerous activity within a cell and releasing an anti-cancer drug upon diagnosis.
-2006, Researchers at the University of Portsmouth, UK, develop a nanoactuator, a DNA based electronic switch that could be used in a biodefence role as a biological sensor to detect airborne pathogens.

THE FIRST EXAMPLE OF DNA COMPUTING

Leonard Adleman's first experiment with DNA based computing involved using DNA, genetic sequencing techniques and enzymes which cut the DNA at specific letters or sequences of letters Adleman solved what is known as the directed Hamilton Path problem or the "traveling salesman problem. Different sequence segments, made by cutting the DNA with enzymes, represented the different variables of the problem. All of the segments are mixed together in a test tube in an environment in which they will bind together forming new combinations and with enough DNA, the right answer to the problem. This happens within a second as each combination is created simultaneously.
In a conventional computer each of these combinations would have been tried and tested sequentially, taking much longer than a second.
After all possible combinations have been made, or, computed, they must be sorted for the correct answer. The sorting is done through a series of chemical reactions and genetic sequencing techniques all of which takes a lot of time an human effort and has a high potential for human error.
As the number of variables in a problem grows the potential for error and the amount of DNA needed grows exponentially. At 200 variables the amount of DNA needed would weigh more than the earth itself! This type of computing is not to be used in any practical sense, however the experiment was a first to show the possibilities within DNA and in its wake many other studies on DNA based computing were launched.

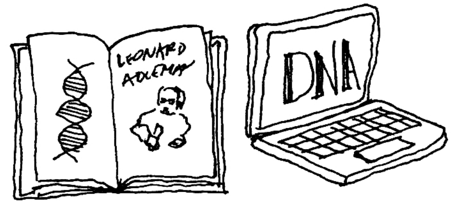
THE FUTURE OF DNA BASED COMPUTING

DNA computing has a very near future in nanotechnology, working as the software for nanomachines built for medical purposes such as working within cells to repair damage, detect illness, and deliver medication. More and more uses for DNA computing will arise as scientists continue to learn faster, better ways to manipulate genetic material.
It may take several decades before DNA based computers can compete with our electrical silicon based PCs in terms of practicality and usefulness. DNA computing is a brand new field of science and DNA itself still remains a bit of a mystery as a material, despite the efforts of the Human Genome Project. DNA based computers in the future may never be used for the things we use our PCs. The first electronic computer was called the Atanasoff-Berry built at Iowa State University in 1942, it could solve equations containing a maximum of 29 variables and weighed more than seven hundred pounds.
Comparing this hulking beast of a once fledgling technology with its light, compact and utterly flexible descendants the laptop and the palm pilot, one can barely imagine the progress that will be made in DNA computing in the next 60 years. The world has changed immensely due to the technological innovations made possible by our recent advancements in computing and the creation of the world wide web. DNA computing presents yet another door to technologies that will trigger a whole new set of scientific revolutions that will alter our civilization.

WEBSITES AND BOOKS TO LOOK UP FOR FURTHER RESEARCH ON THIS TOPIC:

-http://www.howstuffworks.com/dna-computer.htm
-
http://hypography.com/topics/dnacomputers.cfm
-
http://www.eetimes.com/story/OEG20001221S0032

-Leonard Adleman, Molecular computation of solutions to combinatorial problems.
-DIMACS Proceedings: DNA Based Computers I (#27), II (#44), III (#48), IV (Special Issue of Biosystems), V(MIT, June 1999)



the Small Science Collective 2008 (LM)
http://smallsciencezines.blogspot.com